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Electromagnetic Imaging of Fluids in the San Andreas Fault: Collaborative Research with University of Washington and Oregon State University

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1 Introduction

This grant has funded the participation by Oregon State University researchers in field experiments to collect high resolution magnetotelluric (MT) profiling data across the San Andreas fault (SAF) near Parkfield, California. The experiment is part of a larger collaboration with University of Washington investigators Martyn Unsworth and John Booker, involving three dimensional electromagnetic imaging of the SAF in areas of the SAF exhibiting a range of deformational styles, from the Carrizo Plain segment where the fault is locked, to the central creeping segment of the SAF near Hollister. Since the resistivity of crustal rocks is largely controlled by fluid content, these surveys will allow us to place constraints on the distribution and connectivity of fluids within the fault zone, and to show how these properties vary between segments with different mechanical behaviors. These results are expected to ultimately provide important information on the role of fluids in the earthquake process.

Other phases of the experimental effort, and all analysis and interpretation of data are being supported by the U.S. Department of Energy, and the National Science Foundation. This report thus covers only the 1997 Parkfield data collection phase of this project.

2 Parkfield MT Data

Continuous tensor MT profiling data were collected on three profiles across the SAF during the field experiment, which was conducted from September 22 - October 27, 1997. To improve data quality remote reference sites were occupied simultaneously with the profile site. These remote sites were separated from the local profiling site by 10 km or more in most cases. Remote sites were full 5 component MT sites, so these sites also serve to extend the length of the dense profiles, improving possible resolution of deeper conductivity structures in the fault zone, and providing information about the regional geoelectric context. The location of profiles and remote sites is given in Figure 1. Profiles 1 and 3 bracketed an MT profile from a previous experiment conducted in 1994 (Unsworth et al., 1997, 1998). The three profiles in this area are now approximately 2-3 km apart, and should provide good control over three dimensional effects on this segment of the fault. Profile 2 is approximately 20 km southeast of the other profiles. This profile crosses the Cholame valley, a pull-apart basin associated with the en echelon offset of the SAF, near the northern edge of a locked segment of the SAF.

The layout of the continuous MT profiling arrays is summarized in Figure 2. In general, 8 electric dipoles were sampled at one time: 5 along profile (across the fault) dipoles and 3 across profile dipoles. The configuration is such that full tensor analysis can be conducted at any point on the profile. Dipole lengths were always 100 m, and 3 components of the magnetic fields were measured at one end of the profile. Typically dipoles were moved every day, and the magnetometers were moved every two days. Thus spacing of magnetic field measurements is 1 km. Profile lengths, and the number of along and across profile dipoles collected for each site are summarized in Table 1.

3 Data Processing

A newly developed MT-24 system from Electromagnetic Instruments (EMI) was used for this experiment. Although there were some minor difficulties encountered with the new system (particularly with incomplete software), data quality was generally very good, and productivity was high. Data were processed using robust remote reference and robust multiple station programs (Egbert and Booker, 1986; Egbert, 1997). Representative examples of MT soundings are presented in Figure 3. In cases where the remote site failed, data from the UC Berkeley EM seismic monitoring array (with continuously operating 40 hz sampling sites at Parkfield and Hollister) were used to improve data quality. Results of the data processing for individual sites and profile segments were merged into three profiles of tensor MT soundings in standard EDI format for further inversion and interpretation. Pseudosections of TM and TE MT parameters for the three profiles are presented in Figures 4-6. Processed data are available from egbert@oce.orst.edu.

Future work at OSU (under NSF funding) will include estimation of full inter-station magnetic transfer functions (e.g., Egbert and Booker, 1993), using the Berkeley MT monitoring site as a fixed reference. In collaboration with UW workers we will also complete inversion and interpretation of the Parkfield MT data.

References

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